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Investigation of the corrosion process in the feed tract at thermal power plants with 300 MW units

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ABSTRACT: The reliability of the operation of heating equipment at thermal power plants (TPP) is the most important problem of thermal power engineering, in solving which the organization of the water regime at thermal power plants plays an important role.

The water-chemical regime of a thermal power plant is a system of organizational and technical measures aimed at ensuring and maintaining the quality standards of a water coolant. It allows you to achieve trouble-free and economical operation of the equipment during the design life.

The water regime of drum boilers should be organized in such a way that the following basic requirements are met: no deposits of impurities in the superheater and turbine; reduction to a minimum of corrosion of the steam-water path; absence of sludge and scale.

To meet these requirements, the intake of impurities into the feed water should be minimized

KEYWORDS: water treatment, electrochemical corrosion, hydrazine-ammonia treatment, neutral water treatment, block desalination plant, high-pressure heater, condensate cleaning.

I. INTRODUCTION

The water regime should ensure the operation of thermal power plants and thermal grid enterprises without damage and reduced efficiency caused by corrosion of the internal surfaces of water treatment, thermal power and network equipment, as well as without the formation of scale and deposits on heat transfer surfaces, deposits in the flow part of turbines, sludge in equipment and pipelines of thermal power plants and heating networks.

When organizing water regimes at thermal power plants, mainly alkaline and neutral methods are used. In the Republic of Uzbekistan, most subcritical thermal power plants with drum boilers are organized by alkaline methods. At supercritical thermal power plants with direct-flow boilers, a neutral oxygen water regime (NOWR) is used. This water mode with oxygen dosing assumes the absence of brass in the main circuit of the unit, high purity of condensate and often closed vapor of the deaerator according to the non-deaerator circuit of the unit. [1]

II. METHODS

In NOWR, due to the effect of large amounts of oxygen on the surfaces of carbon steel, a dense, highly adhesive, protective magnetite film Fe_3O_4 is formed. It should be noted that only Fe^{2+} ions located in the crystal lattice of the metal are involved in the formation of a protective film of magnetite and under the condition:

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a) in such concentrations, at which the following equilibria are observed:

$$3Fe^{2+}+4H_2O \rightarrow Fe_3O_4+8e+8H^+; \quad (1)$$

$$4H^+ + 4e + O_2 2H_2O; \quad (2)$$

b) in the presence of oxygen, the lowest rate of corrosion (Fig.1).

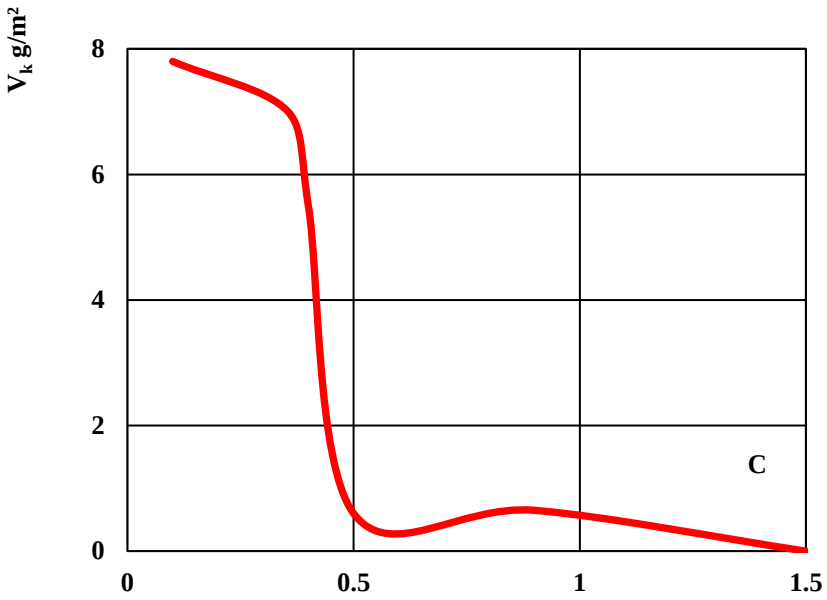

Fig.1. Corrosion rate depending on oxygen content

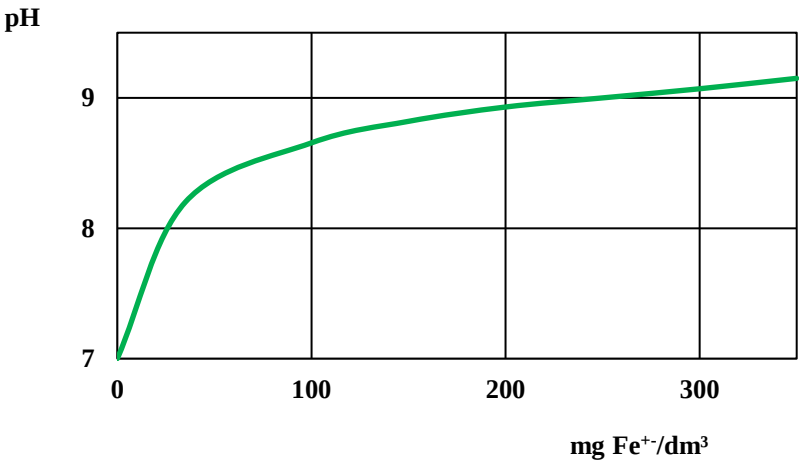

Fig.2. Dependence of the pH of solutions on the concentration of Fe

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As can be seen from Figures 1 and 2, the corrosion rate tends to zero in the presence of elevated oxygen concentrations (above 0.1 - 0.2 mg/dm^3) and at pH in the range of 7-7.5.

The nature of the corrosion process significantly depends on the composition of the coolant and its properties. In order to ensure long-term reliable operation of power plants, it is necessary that the corrosion of metal materials proceeds evenly and with low intensity.

The experience of the NOWR operation at various thermal power plants has shown that in this mode all the parameters of the working environment, the temperature of the metal of the equipment, the turbine power and the pressure behind the control stage correspond to and even lower than the norms of the rules of technical operation (RTO). It is recommended to carry out chemical cleaning of the unit only during major repairs [4, 6].

The neutral water regime with an increased oxygen concentration in the feed water makes it a prerequisite for deep desalination of the entire condensate stream at the block desalination plant. The protective layer of magnetite has been under strong internal stress since its formation, which increases when the boiler stops (the metal cools) and the load increases with increasing temperature.

III. RESULTS

At thermal power plants with 300 MV units according to a deaerator scheme in the feed tract, the metal on the outside of the coil of the high-pressure heater (HPH) undergoes a process of steam corrosion - hydrogen embrittlement at temperatures above 475 ° C with the formation of a magnetite film (Fe_3O_4) and the release of free hydrogen only according to equation (1) without binding it (2) with the formation of water vapor.

After a certain period of time after the contact, an equilibrium of hydrogen distribution occurs between the hydrogen-containing working medium of the main circuit of the block and the metal, i.e. the metal is saturated with hydrogen.

Between the hydrogen-containing working medium of the main circuit of the block and the metal, after a certain period of time after contact occurs, an equilibrium distribution of hydrogen occurs, the metal is saturated with hydrogen.

Atomic hydrogen dissolved in steel causes a decrease in strength and ductility and can lead to delayed destruction under loads and temperatures that are safe in the absence of hydrogen. Hydrogen also reduces long-term strength and long-term ductility and can accelerate creep (Fig.3) with metal rupture.

According to literature data [2, 8], the hydrogen content in metal near the fracture site is usually 1-2 orders of magnitude higher than in pure metal.

Fig.3. Damaged sections of coils

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The following has a significant effect on the corrosion damage of the coils of the HPH on the steam side:

a) oxidative aqueous regime with oxygen dosing, where corrosion processes occur at a high rate, which is determined by the influence of oxygen and weak acids, primarily carbon dioxide CO_2. It is believed that organic substances can enter the condensate without being delayed by condensate cleaning, which then decompose in the condensate-nutrient tract and undergo thermolysis with the release of aggressive CO_2 gas. The development of these processes leads to an increase in the content of these impurities in the coolant, exceeding the existing standards.

b) electrochemical corrosion with hydrogen depolarization, which occurs when metal comes into contact with a film of moisture. The main agents of this process are: 1) aggressive CO_2 gas, which can cause corrosion with both hydrogen (flooding, hydrogen embrittlement) and oxygen depolarization (formation of corrosion products) and - 2) oxygen O_2 in small quantities - with oxygen depolarization. In these studies, the main agent of corrosion is aggressive CO_2 gas.

HPH often contains sludge accumulations consisting of corrosion products that adhere to the metal and lead to sludge corrosion, the latter being the basis of hydrogen corrosion of the metal in the HPH water environment, and on the steam side, heat exchange between feed water and steam is disrupted, which leads to an increase in metal temperature and steam corrosion [1, 9].

Table 1
Carbon dioxide content in the working environment of 300 MW units

№	Points of the block's working environment	Unit No. 1 with a deaerator	Unit No. 2 with a deaerator	Unit No. 4 with a deaerator	Unit No. 1 without a deaerator
1	Condensate pump KP-I	0,77 *	0,99	Absent	0,79
2	Nutrient water with pH	0,88 pH=8,0-8,2	0,77 pH=7,0	0,33 pH=8,5	0,92 pH=7,9
3	Sharp steam	0,77	0,81	0,31	0,80
4	High pressure heater	1,2	0,82	0,44	1,22

* According to the RTO standards, there should be no aggressive CO_2 gas in the nutrient tract of the supercritical parameter blocks after the deaerators, and up to 1.0 micrograms/dm^3 is allowed without the deaerator circuit of the block.

IV. CONCLUSIONS

Studies have shown that the CO_2 content in the working environment of the units was higher than normal, especially in the area of high-pressure heaters (Table.1), only in block No. 4 at pH = 8.5 the lowest CO_2 content.

In case of an increase in the content of aggressive CO_2 gas in the hot steam of the steam boiler, it is advisable to periodically carry out chemical cleaning of HPH.

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